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THE INFLUENCE OF SOCIOECONOMIC FACTORS ON DEFORESTATION: A CASE STUDY OF THE DRY AFROMONTANE FOREST OF DESA'A IN TIGRAY REGION, NORTHERN ETHIOPIA

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ABSTRACT

Forests are vital for people and environments, for both their productive and ecosystem functions. However, these vital resources are facing tremendous anthropogenic pressures where they are currently found scattered in inaccessible and sacred areas in Ethiopia. Among these is the remnant dry afromontane forest of Desa'a, northern Ethiopia. As part of ongoing restoration efforts, the presence of severe deforestation and forest deterioration in the locality is well studied. However, the socioeconomic factors deriving the deforestation process in this forest reserve is poorly investigated where only qualitative assessments can be found. Therefore, this study was conducted to identify the socioeconomic and demographic factors influencing deforestation, their influence and extent in the afromontane environment of Tigray highlands, Desa'a. In-depth interview with 123 members of seven villages within Desa'a forest were covered in the study. Results of this study revealed that; age, off farm activity and education have inverse relationship while family size, farm ownership and gender (female), have direct relationship to deforestation. Therefore, to reduce pressure on the forest, gender appropriation in natural forest management and access to education, land ownership and age, should get appropriate focus in natural forest management planning and interventions. Especially land owners should be oriented to live in a friendly way with the forest as it is directly related to their land productivity.

KEYWORDS: Socioeconomic Factors, Demographic Variables, Deforestation, Dry Afromontane Forest, Forest Management

INTRODUCTION

Forests are vital for people and environments. They conserve biodiversity, protect watershed services, lock up carbon and provide food, fibre, energy, timber and medicine. Moreover, they are the cultural heritage of and means of livelihoods for millions of people worldwide (Nhantumbo & Macqueen, 2011) and basic inputs for different industrial products (FAO, 2001; Feyera & Demel, 2002). However, despite their indispensable importance, they are under continual pressure from different perspectives. Deforestation, mainly clearing forests for different purposes, such as agricultural expansion, charcoal making, fuel wood, timber production, fire and construction are the major problems of almost all countries (FAO, 2010).

The highlands of Ethiopia support more than 88% of the human population, 75% of the cattle population and 95% agricultural conducive land (Hurni, 1988; Teketay, 2005). Moreover, they are home to the few remnant dry Afromontane forests in the county (Friis, 1992). Among these is the dry afromontane forest of Desa'a which is found in the northern region of Ethiopia, Tigray. It is the biggest forest reserve in the region covering more than 120,000 ha

(Aynekulu *et al.*, 2012). While the forest is an important bird area (BLI, 1998) and diversified fauna and flora biodiversity composition (Aynekulu *et al.*, 2011), it is severely affected by the anthropogenic pressures (Zenebe, 1999). Population pressure imposed by population increment, extensive cattle herding, historical political instability and low agricultural productivity have caused huge deforestation and forest fragmentation (Yirdaw, 2002) which left remnants of forests in sacred (For e.g. churches) and inaccessible areas (EFAP, 1994; Aerts *et al*., 2006). Traditional energy use system which is dependent majorly on forest products (Zenebe, 2007) and such factors as illegal logging, animal encroachments (Zenebe, 1999) and die back of major species (Aynekulu *et al*., 2011) are among the threats of the future existence of this forest island.

The extent of degradation and qualitative assessment of deforestation factors (Zenebe, 1999), altitudinal variation of species composition (Aynekulu, 2012), and the effect of diebacks on the structure of the forest community (Aynekulu *et al*., 2011) are well studied in Desa'a forest reserve. However, anthropogenic pressures mainly the socioeconomic factors and their effect size on the deforestation which can be valuable information for stetting bases for community based forest management interventions remain untouched for this nationally prioritized forest reserve. Therefore, the objective of this study was to identify the socioeconomic and demographic variables influencing deforestation in this particular environment of dry afromontane region. Results of this study are believed to assist forest management intervention by prioritizing factors of interest.

MATERIALS AND METHODS

Study Location

Desa'a forest represents heterogeneous landscapes accountable for the significant difference in biophysical setting of the study site. It is located between 13^0 56' N and 39^0 51' E (Figure 1) having an area of 120,026ha (Zenebe, 1999) at an altitude range of 900 and 2862 m a.s.l. The forest area extends from Atsbi-wonbertaWoreda of Tigray down to the Afar Regional State (TBoANR, 1997, Zenebe, 1999). The forest is a typical dry afromontane forest dominated by *Juniperusprocera* and *Oleaeuropaea* ssp. *cuspidata* in the upper canopy of the highlands (Friis, 1992; Ayenekulu *et al.*, 2012) which are the most exploited species in the study area (Zenebe, 1999).

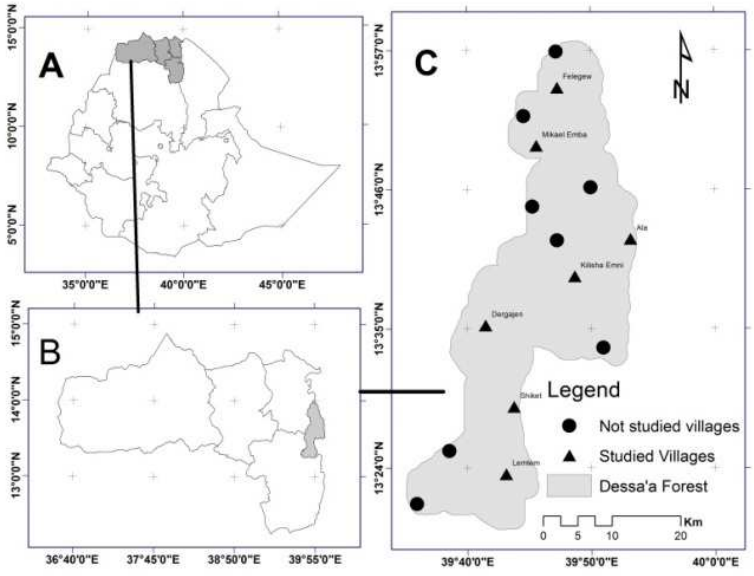

Figure 1: The Location of the Study Area, Desa'a Forest (C), Tigray (B), Ethiopia (A)

Data Collection

Socioeconomic factors affecting deforestation process in Desa'a forest were sampled using different methods at different stages in the selection process of study villages and sample households. Purposive sampling was used to select seven out of fifteen villages found in the district. After selecting the villages, the sample size was determined by following the formula by Cochran (1977) as cited in Leech *et al.* (2005) as follows:

$$n = \frac{Z^2 * P * Q * N}{E^2 (N-1) + (Z^2 * P * Q)}$$

Where, n = sample size; Z = values of standard variation at 95% confidence interval (1.96); P = sample proportion (0.03); Q = 1-P, E = the estimate should be within 3% of the true value; N = the total household population.The total population of the studied villages was 58,545. Of this population, the total sample size for this study was found to be 123. To select these 123 sample respondents, the total population was then stratified by age and gender factors. Age categories were created based on the local category system and following Bielli *et al.* (2001). These age groups are: below 15, 15-35, 36-64 and above 64 years of age. In discussing with the administrative bodies and elders of the villages, the minimum age group was taken to be 15 years as children younger than 15 do not dare to enter the forest alone. Therefore, part of the population aged below 15 years was left out in the sampling process. Proportional sampling was used to allocate respondents to each age and gender strata. After sample size of male and female was known using the proportion method, respondents were selected using simple random sampling. Each and every selected respondent was administered for in-depth interview.

Data Analysis

Descriptive statistics and Binary logistic regression model in SPSS (Statistical Package for Social Sciences) was used to identify the socioeconomic factors determine deforestation. Logistic regression is used when there are continuous explanatory variables and dichotomous outcomes to look into the relationship between the dependent variable and the different independent variables (Dowdy *et al.*, 2004). It is well suited with odds rather than proportions. Odds are the ratio of the proportions for the two possible outcomes (Peng and So, 2002). There are some assumptions in binary logistic regression though fewer than multiple and discriminant regression models (Leech *et al.*, 2005). The first assumption is the dependent variables or the outcomes should be dichotomous. Secondly, the outcomes are mutually exclusive (independent to each other). The third assumption is that binary logistic regression needs large sample so as to be more accurate (Leech *et al.*, 2005).

To ensure independency of the selected explanatory variable (to avoid multicollinearity), different methods were employed for continuous variables; Tolerance and Variance Inflation Factors (VIF) was used. Tolerance is a measure of collinearity reported by most statistical programs such as SPSS; the variable's tolerance is $1\text{-}R^2$ (Gujarati, 1995). A small tolerance value indicates that the variable under consideration is almost a perfect linear combination of the independent variables already in the equation and that it should not be added to the regression equation. Some suggest that a tolerance value less than 0.1 should be investigated further (Grob, 2003). If a low tolerance value is accompanied by large standard errors and non-significance, multicollinearity may be an issue. The Variance Inflation Factor (VIF) measures the impact of collinearity among the variables in a regression model. The Variance Inflation Factor (VIF) is 1/Tolerance, which is always greater than or equal to 1. Variance Inflation Factors shows how the variance of an estimator is inflated by the presence of

multicollinearity (Gujarati, 1995). There is no commonly agreed VIF cut value for determining presence of multicollinearity (Gujarati, 1995; Leech *et al.*, 2005). However, Values of VIF that exceed 10 are often regarded as indicating multicollinearity, but in weaker models values above 2.5 may be a cause for concern (Gujarati, 1995; Grob, 2003). VIF is computed as follow:

$$VIF = 1 \Big/ 1 - R^2$$

Where, VIF = Variance Inflation Factor; and R^2 = adjusted R square of the multiple correlation coefficients; Similarly to evaluate the degree of association among the qualitative (dummy variables), contingency coefficients were calculated. Contingency coefficient is the Chi-square based measure of association. A value of 0.75 or more indicates a stronger relationship (Healy, 1984; cited in Paulos, 2002). It was computed as follows:

$$C = \sqrt{X^2 \Big/ N + X^2}$$

Where C= Contingency Coefficient; X^2 = Chi-square test; N= total sample number

In accordance to Giliba *et al.* (2011), the coefficient (β), which is the sign of effect, was used to compare which of the independent variables have greater influence; Wald statistics to see if increases in independent variables is significant or not; odds of ratio (Exp (β)) to measure how a unit increase in the independent variables affects the probability of deforestation pattern. The goodness of fit of the prediction model which was as measured using both chi-square and the log likelihood ratio-test denoted by (-2 Log likelihood) was calculated.

RESULTS AND DISCUSSIONS

Impact of Socioeconomic Factors in the Deforestation of Desa'a Forest

Before running the model, the problem of multicollinearity among the continuous variables and the degree of association among the dummy variables were analysed. Three continuous socioeconomic explanatory variables were checked for multicollinearity using Variance Inflation Factors (VIF) and Tolerance value while contingency coefficients were used to detect the degree of association among six qualitative (Dummy) socioeconomic explanatory variables. According to the results, no significant problems of multicollinearity and very high degree of association were observed. The maximum value of VIF for the continuous socioeconomic (age, farm and family size) and physical factors (settlement, elevation, distance from deforested edge, road and slope) were 1.033 and 1.34 respectively which are less than 10, the determinant cut off point. Similarly, the tolerance value for the socioeconomic factors (0.968) was higher by far from the assumed cut off value (0.1). Therefore, as all the hypothesized continuous and dummy explanatory variables were found to be independent to each other, they were included in the model. After the multicollinearity problem was cleared off, each variable was entered individually to see if they significantly influence deforestation pattern in Desa'a forest. Insignificant variables such as awareness of the respondents on the consequences of deforestation and the legal frameworks abiding forest management (p=0.557) as the forest is among the protected national priority forest areas, and farm size (p=0.067) which reduced the accuracy level of the prediction, were removed. Some findings showed that farm size affects deforestation independently and when entered to the model (Giliba *et al.*, 2011) increases the overall prediction level but becomes insignificant in the model. Awareness was also expected to affect the deforestation process. However other related research studies (Giliba *et al*., 2011) showed that they are insignificant in predicting deforestation patterns.

To identify which socioeconomic factors affect the deforestation process in Desa'a forest, logistic regression analysis was used. Statistical function was run with six different socioeconomic factors which were age, gender, off farm activity, farm ownership, education and family size. With these variables, the goodness of fit of the model was found to be high with results of the prediction (81.8 %). This indicates that the model with the specified variables predicts deforestation up to 81.8% accuracy level. The Hosmer and Lemeshow goodness of fit test also showed high significance (p= 0.792). The chi-square test value of 53.757 with 6 degree of freedom is also highly significant at 95% confidence level (p<0.001). Similarly, the pseudo R-square (0.387) is relatively high at the same significance level (Ayalew *et al.*, 2005). The Wald statistics values (Table 1) which indicates the interaction level of the dependent and independent variables (Ayalew *et al.*, 2005) are none zero. Therefore the alternative hypothesis which states, there is an interaction between the socio economic factors and deforestation process (Giliba *et al.*, 2011), was accepted. The effect of each factor on deforestation process of Desa´a forest is listed below in details.

Table 1: Socio-Economic Factors Influencing Deforestation in Desa'a Forest Reserve

Variables	β	S.E.	Wald	df	Sig.	Exp(β)
Age	-0.147	0.034	18.989	1	0.000**	0.863
Gender (female)	1.387	0.551	6.349	1	0.012*	4.004
Off-farm activity	-1.5	0.577	6.76	1	0.009*	0.223
Farm ownership	2.086	0.793	6.925	1	0.008*	8.056
Education	-1.864	0.65	8.239	1	0.004*	0.155
Family size	0.685	0.2	11.701	1	0.001*	1.983
Constant	1.077	1.197	0.81	1	0.368^{ns}	2.936
Exp (β)=odds ratio (probability of success/probability of failure); SE=standard error of the estimate; **statistically significant at 0.01 level of significance; *statistically significant at 0.05 level of significance; ns=statistically non-significant at 0.05 level of significance; Sig=significance; β=regression coefficients which stand for the odds ratio of probability of success to the probability of failure and Wald statistics = $\beta/(SE)^2$; d.f.=degrees of freedom						

Age

Age is one of the demographic factors that affect the knowledge, attitude and practice of individuals towards environmental management (Torgler & Garcia, 2005). The interaction of age with deforestation was found highly significant (p<0.0001). The negative coefficient (β = -0.147) indicates that there is an inverse relationship where interference of the community members on the forest decreases as age of individuals decreases (Table 1). Similar results are reported from several other studies such as Flintan (2003) and Torgler & Gracia, (2005). Highest Wald statistics value (18.989) was observed for age factor which shows higher interaction between age and deforestation. The odds of ratio for age (Exp (β) =0.863) entails that a unit increase in the age of individuals as accompanied by a decrease in the chance of interfering in the forest by a factor of 0.863.

Family Size

Population increment does have clear negative implication on deforestation (Armenteras *et al.*, 2006; FAO, 2010). Family size, being a component of population size, does have its role in facilitating deforestation. In this study, family size is found to have direct relationship with deforestation (β=0.685). The Wald statistics for family size (11.701) was the second highest next to age showing higher interaction with deforestation activities. The influence of family size in degrading the remnant forest can be seen in the fact that a unit increase in family size almost doubles (Exp (β) =1.983) the likelihood of deforestation.

Gender

Gender being an important element of society, is believed that it brings decisive differences in the use of natural resources. Though there are different arguments on the positive and negative contribution of men and women to the environment, Sex is one factor that substantially affects people's knowledge, attitude and practice towards conservation (Hayes, 2001). In the present study, gender is found to significantly affect deforestation (p=.012) being second to farm ownership in its effect size (β=1.387). In Desa'a forest, females have higher contribution in the deforestation process than males (Table 1 and Figure 2).

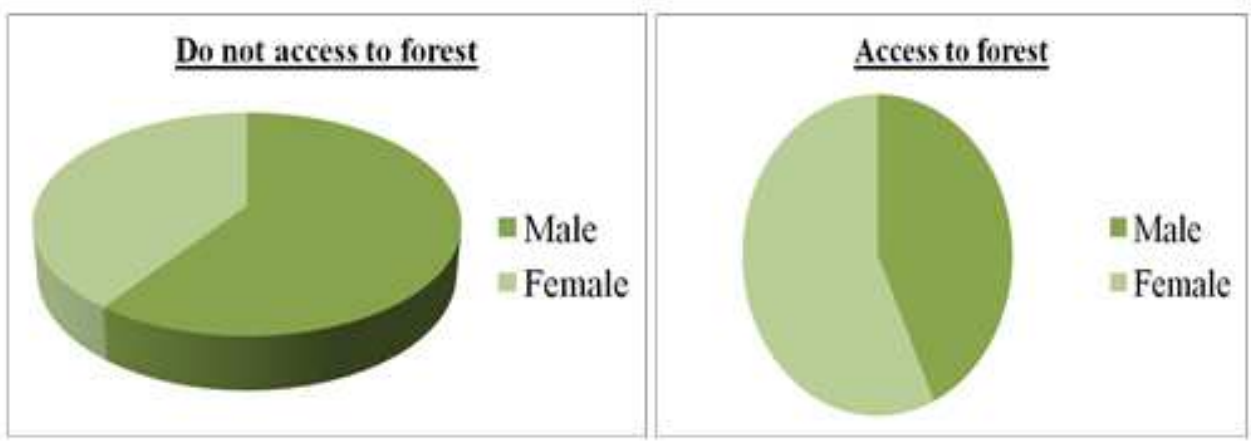

Figure 2: Gender and Participation in Deforestation

Education

Almost similar proportion of male (64) and female (59) were involved in the study. From the total respondents, 41% of them have participated in a formal education for at least four years and they can write and read of which 42% of them were females. Education has a negative relationship with deforestation (β= -1.864) with odds ratio (Exp β) of 0.155 and Wald statistics of 8.239. This entails that encouraging community members to get an education reduces the possible pressure of deforestation. By increasing the number of educated individuals (by a single unit for example) reduces the likelihood of being a threat to the forest by a factor of 0.155. This might be due to possibility of educated members who have better alternatives than those who are not educated. Similar result from Godoy et al. (1998) showed that a unit increases in the year of education reduces the probability of cutting tree by 4%.

Farm Ownership and Farm Size

Majority of the respondents possess their own farm land though of different sizes. 67% of respondents of which 48% of them are females, have farm land to cultivate crops. As it is indicated in Table 2, being a land owner increases the possibility of participating in the deforestation activities (Table 1&2). This justifies by the fact that land owners permanently settle around their farm lands, need more fuel wood, agricultural equipment, feed and fodder than the landless. Similarly, farm size is directly related to activities of deforestation. By increasing the farm size by a single unit increases the possibility of deforestation by a factor of almost two (Table 1). These surprising results are in contrary to the results found by Gilliba *et al.* (2011) where owning larger cultivated land size reduces the chance of deforestation.

Table 2: Farm Ownership and Participation in Deforestation

Access to Forest	Farm Owners	Landless
Yes	60	7
No	22	34
Total	82	41

Means of Livelihood

Among the selected respondents, 67% are dependent on farming for their livelihood. Similarly, 59, 6, 18, 20 and 9% of them are highly dependent on livestock production, salt trading, selling wood collected from the forest, charcoal making and working as daily labourers on the infrastructure construction around their villages respectively (Figure 3).

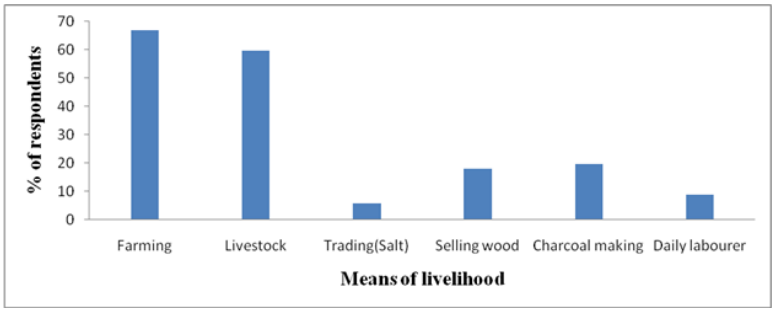

Figure 3: Means of Livelihood in the Study Area

CONCLUSIONS

Deforestation is a process of multidimensional aspects governed by multiple factors. However, for management purposes, it is mandatory to prioritize major factors and act up on them with the available recourses. Though socioeconomic factors are the major sources of the pressures for much of the environmental crisis, deforestation and land degradation; they are mostly overlooked in the proper planning process for conservation. In this study, attempt is made to figure out the influence of socioeconomic factors for the deforestation process of Desa'a forest and prioritize their importance.

Among the social factors in this study, female, uneducated population of the community and people without farmland play greater role in deteriorating the forest. Similarly, those who are participating in off-farm activities such as trading and constructional works are less important than those who do not participate in the process of the deforestation.

Therefore, for effective and inclusive management of Desa'a forest and potentially of all forests in the region, focus should be given in creating opportunities of education and off-farm activities. However, while owning land is vital to the community for increased production and national development at large, special consideration should be given to this part of the society to create safe environment. In this study, we showed that increasing land owners by a factor of one increases the chance of participating in deforestation by a factor of eight showing the importance of such factors in forest management. Similarly, while efforts are needed to make the whole community environment friendly, more is required for female members of the community particularly through creating alternative energy and off-farm activities.

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